www.superheavies.de
c.e.duellmann@gsi.de

Heaviest elements studied at *TASCA*

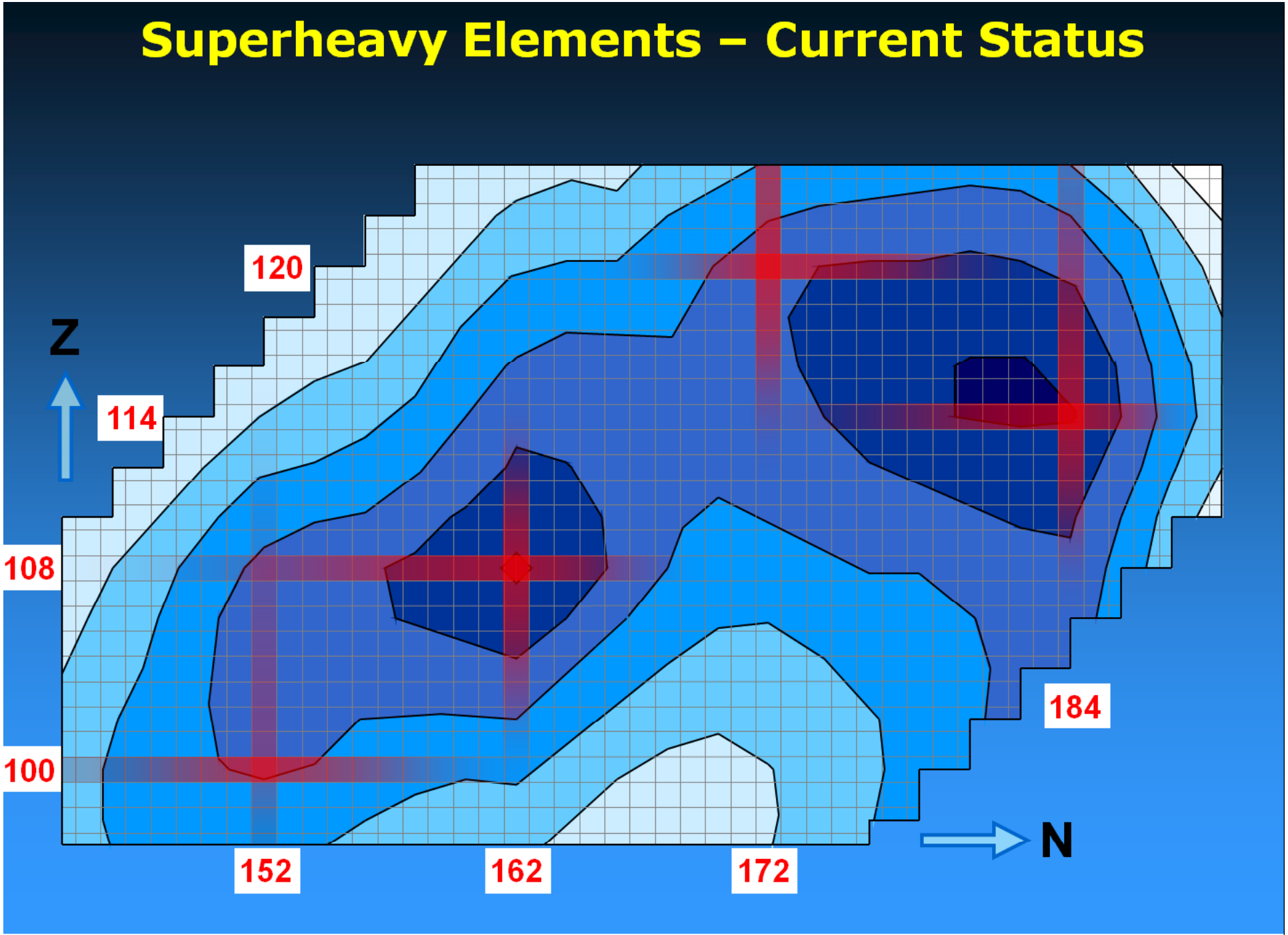
Christoph E. Düllmann

for the *TASCA* and *TASISpec* collaborations

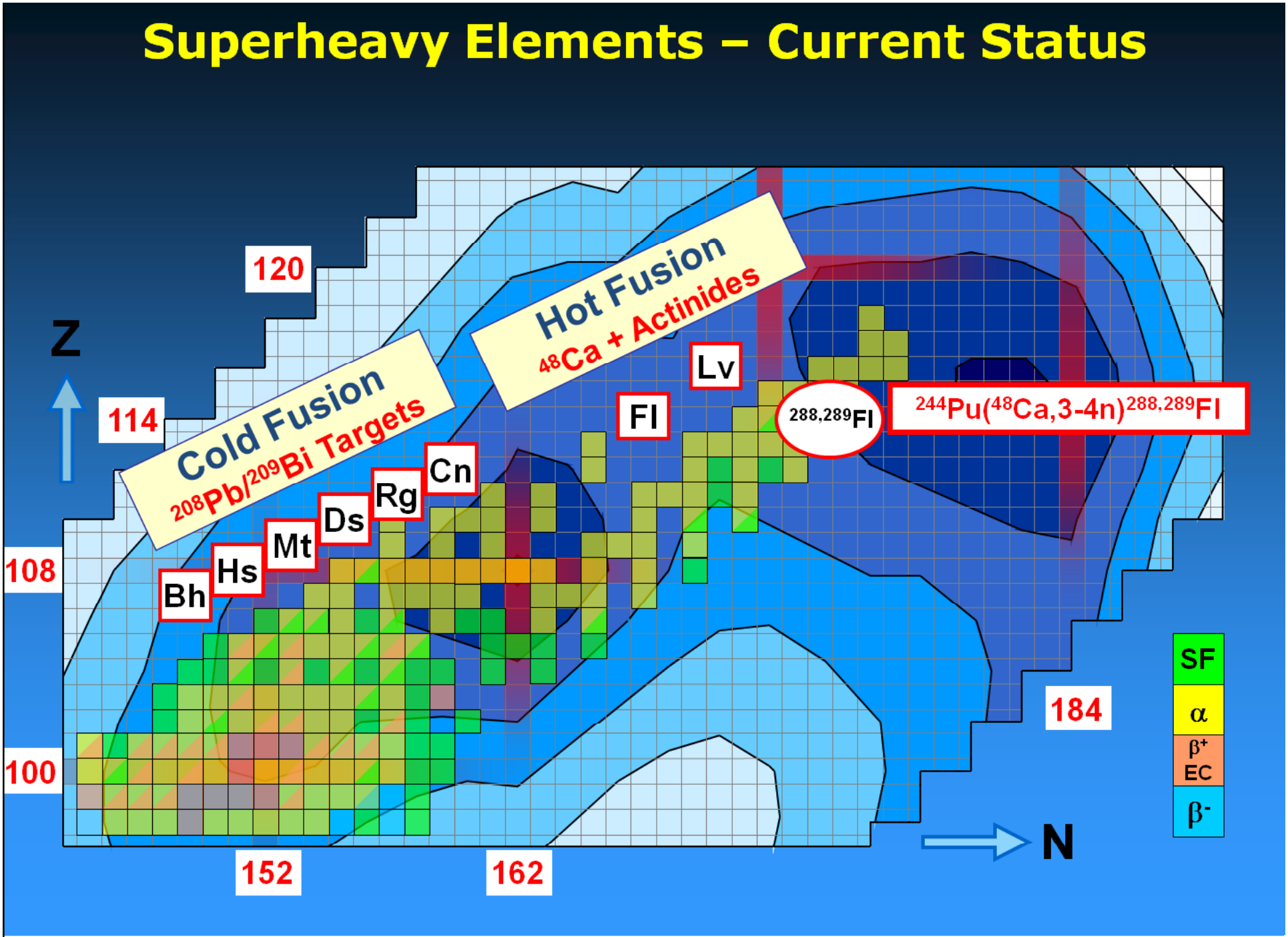
PRISMA Cluster of Excellence & Institute of Nuclear Chemistry, **Johannes Gutenberg University Mainz**
SHE Chemistry, **GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt**
SHE Chemistry, **Helmholtz Institute Mainz**

NUSTAR Annual Meeting 2013
GSI Darmstadt, Germany, February 25 – March 01, 2013

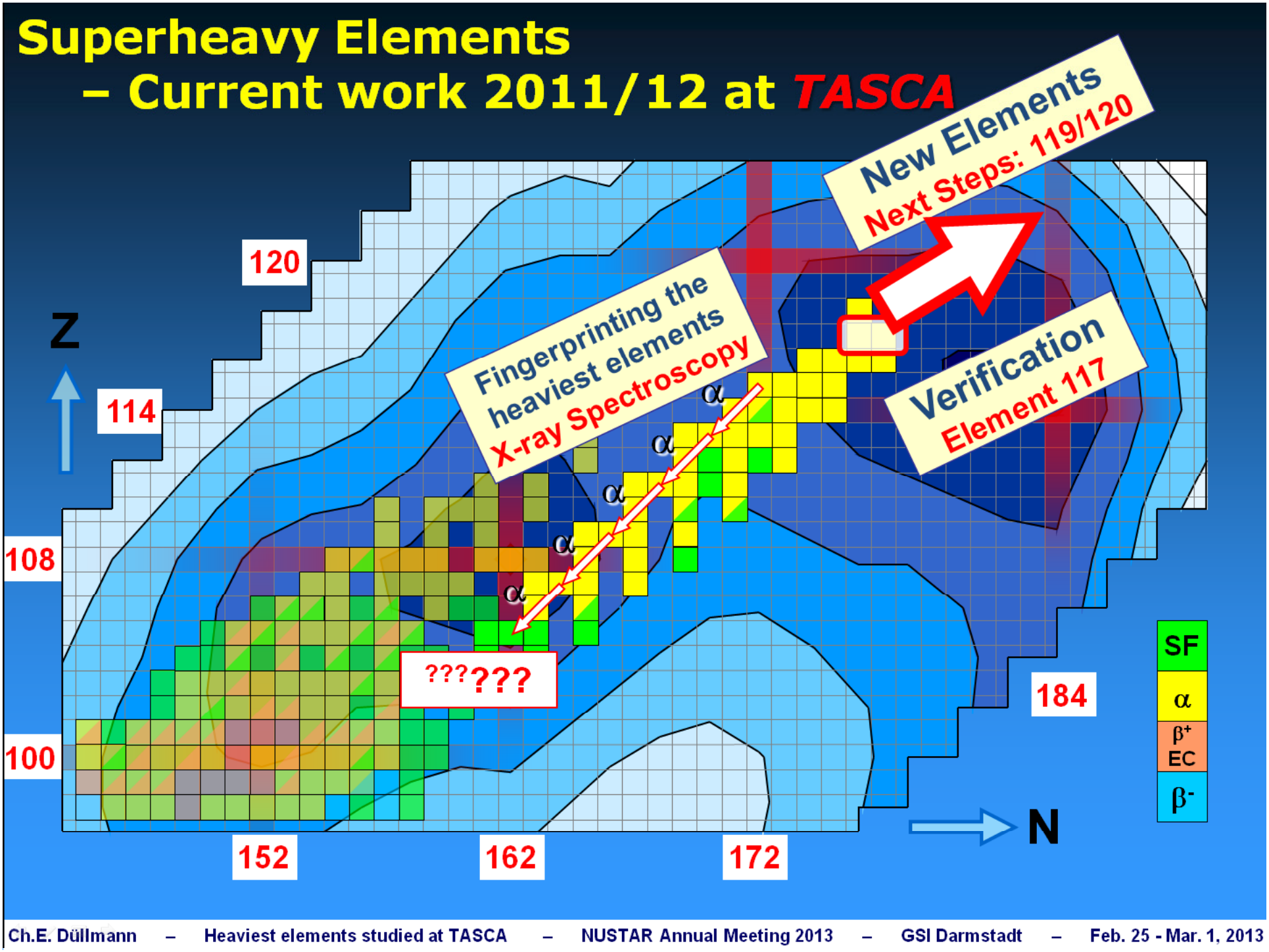
Superheavy Elements – Current Status



Superheavy Elements – Current Status



Superheavy Elements
– Current work 2011/12 at *TASCA*



The *TASCA* Collaboration

LBNL/UCB Berkeley (USA)
LLNL Livermore (USA)
Vanderbilt U (USA)
ORNL Oak Ridge (USA)
U Liverpool (UK)
U Surrey (UK)
U Lund (Sweden)
JAEA Tokai (Japan)

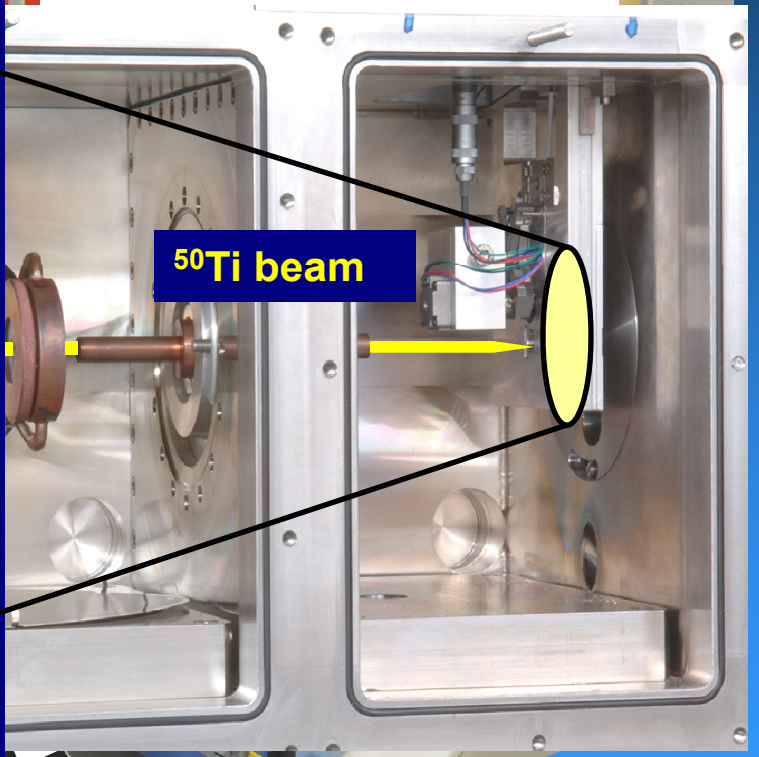
U Jyväskylä (Finland)
U Oslo (Norway)
Chalmers U Gothenburg (Sweden)
PSI Villigen/U Berne (Switzerland)
ITE Warschau (Poland)
SINP Kolkata (India)
IMP Lanzhou (China)
ANU Canberra (Australia)

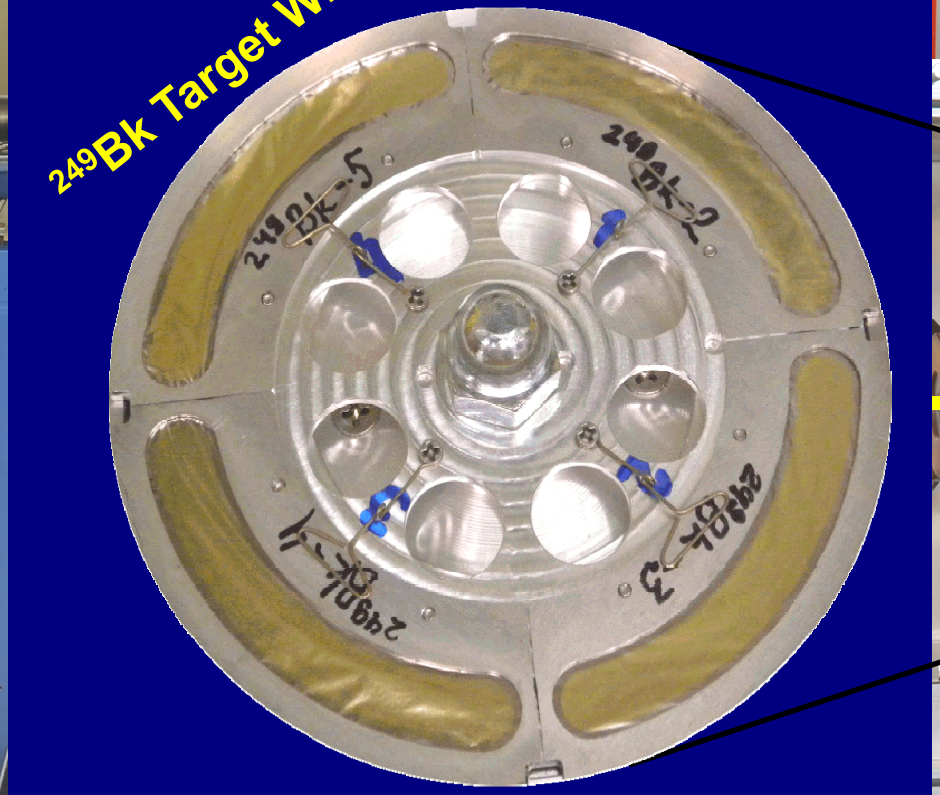

TASCA
DQQ-configuration
$B\rho_{max} \simeq 2.4$ Tm
www.gsi.de/tasca


TASCA
Target Chamber
side view
50Ti beam
www.gsi.de/tasca

TASCA

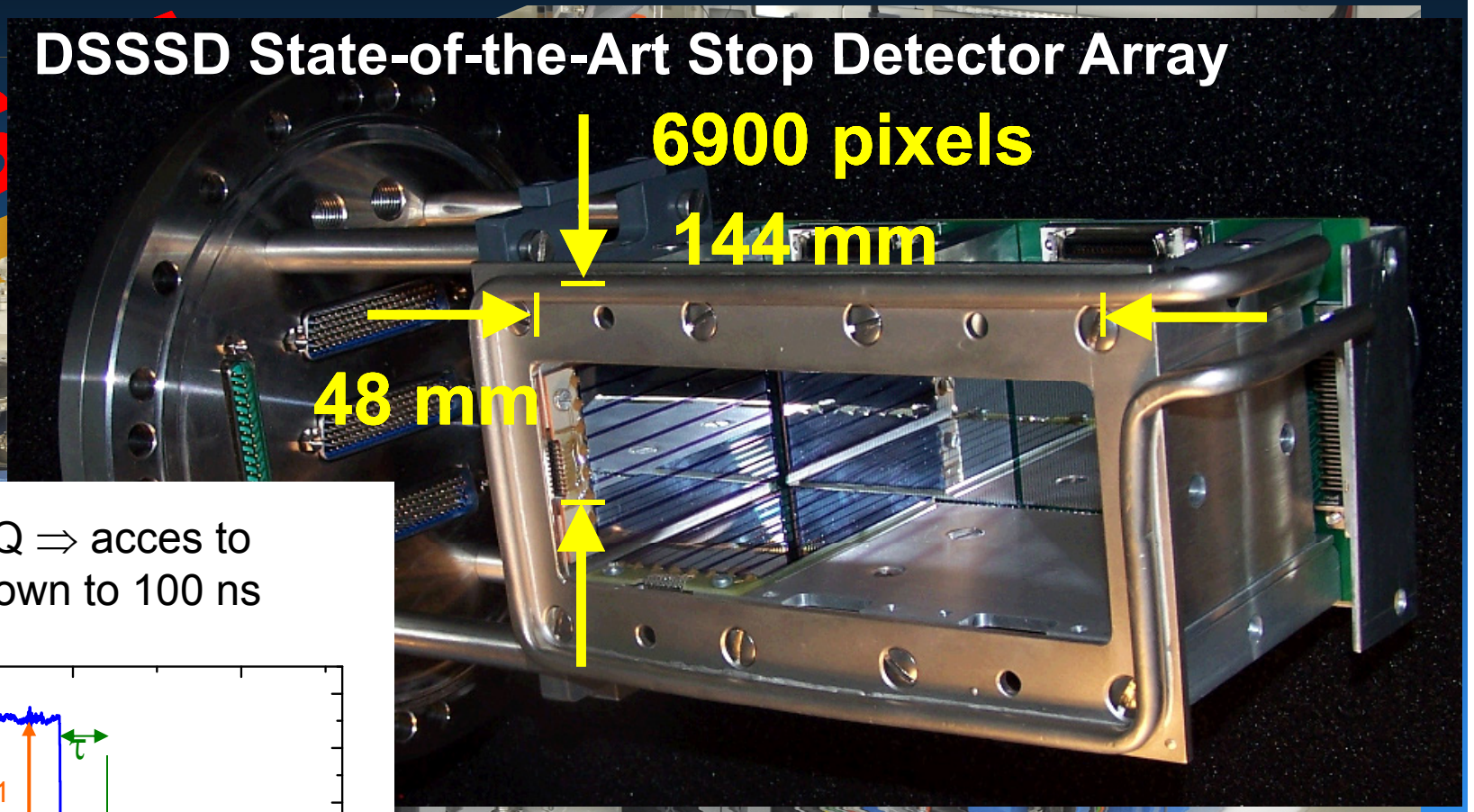
Target Chamber
side view



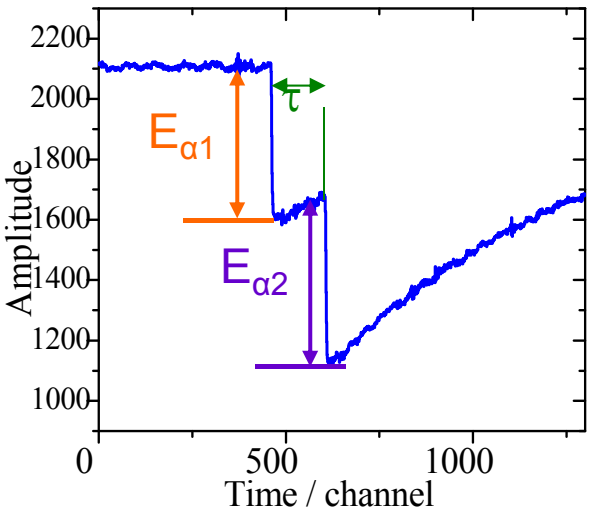


www.gsi.de/tasca

DSSSD State-of-the-Art Stop Detector Array



Digital DAQ ⇒ acces to lifetimes down to 100 ns



Making elements 119 and 120

E119

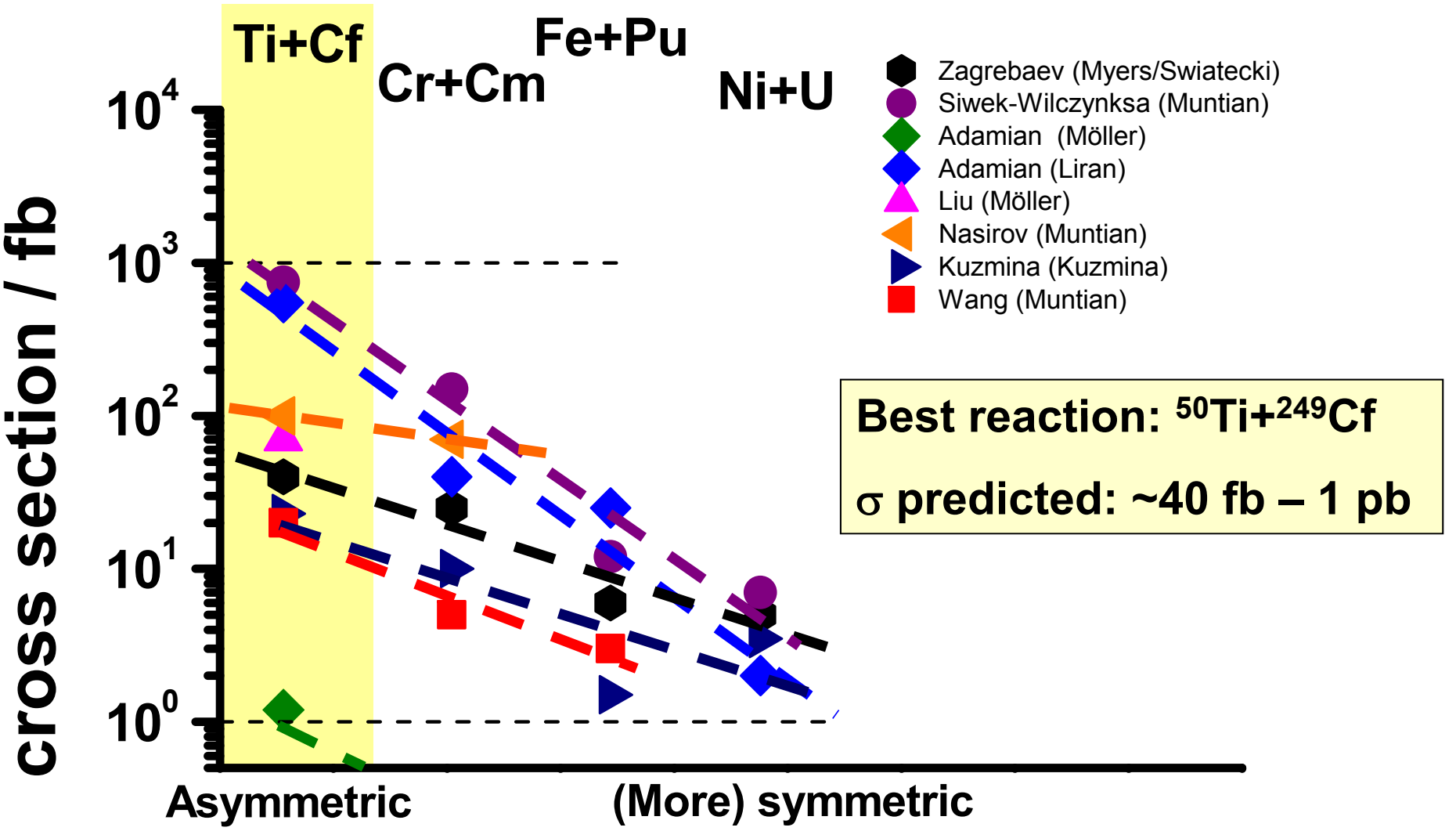
Z_{Beam}	Beam	Target	Asymmetry	$E^*@B_{Bass}$
21	^{45}Sc	^{249}Cf		41.7
22	^{50}Ti	^{249}Bk		32.4
23	^{51}V	^{248}Cm		36.8
24	^{54}Cr	^{243}Am		
25	^{55}Mn			29.9
				36.7

^{50}Ti induced reactions are likely the optimum ones for the production of elements beyond Z=118

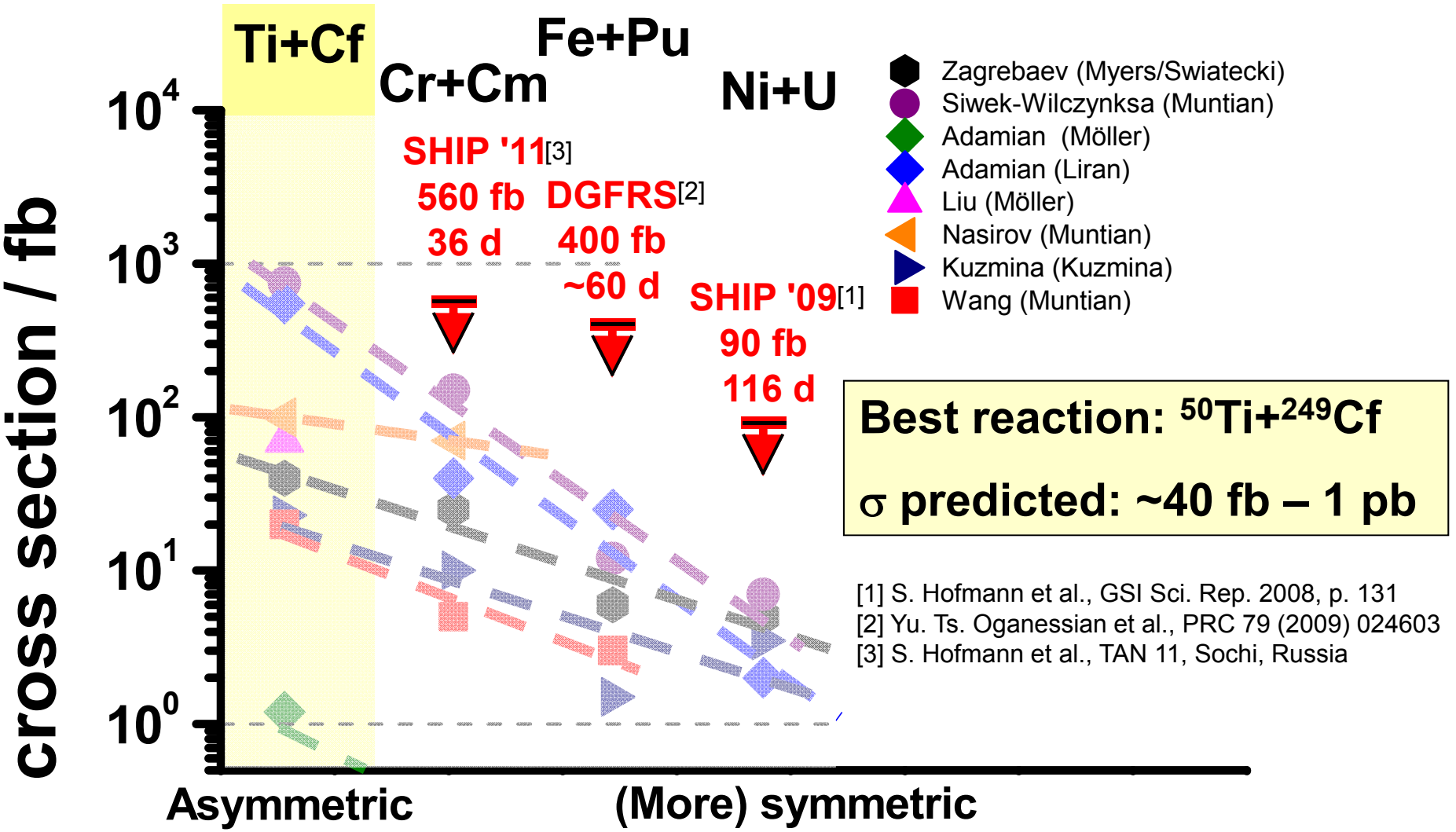
E120

Z_{Beam}	Beam	Target	Asymmetry	$E^*@B_{Bass}$
22	^{50}Ti	^{249}Cf		31.7
23	^{51}V	^{249}Bk		35.9
24	^{54}Cr	^{248}Cm		33.0
25	^{55}Mn	^{243}Am		34.5
26	^{58}Fe	^{244}Pu		33.9
27	^{59}Co	^{237}Np		32.9
28	^{64}Ni	^{238}U		27.3

Element 120 Cross Sections from Theory



2011: The Hunt for Element 120



Best reaction: ^{50}Ti+^{249}Cf

σ predicted: ~40 fb – 1 pb

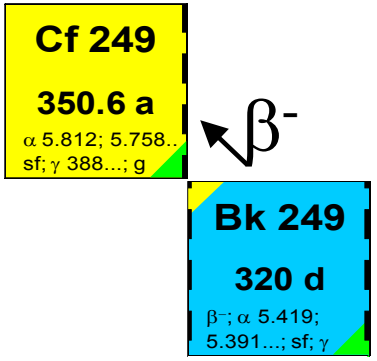
[1] S. Hofmann et al., GSI Sci. Rep. 2008, p. 131
[2] Yu. Ts. Oganessian et al., PRC 79 (2009) 024603
[3] S. Hofmann et al., TAN 11, Sochi, Russia

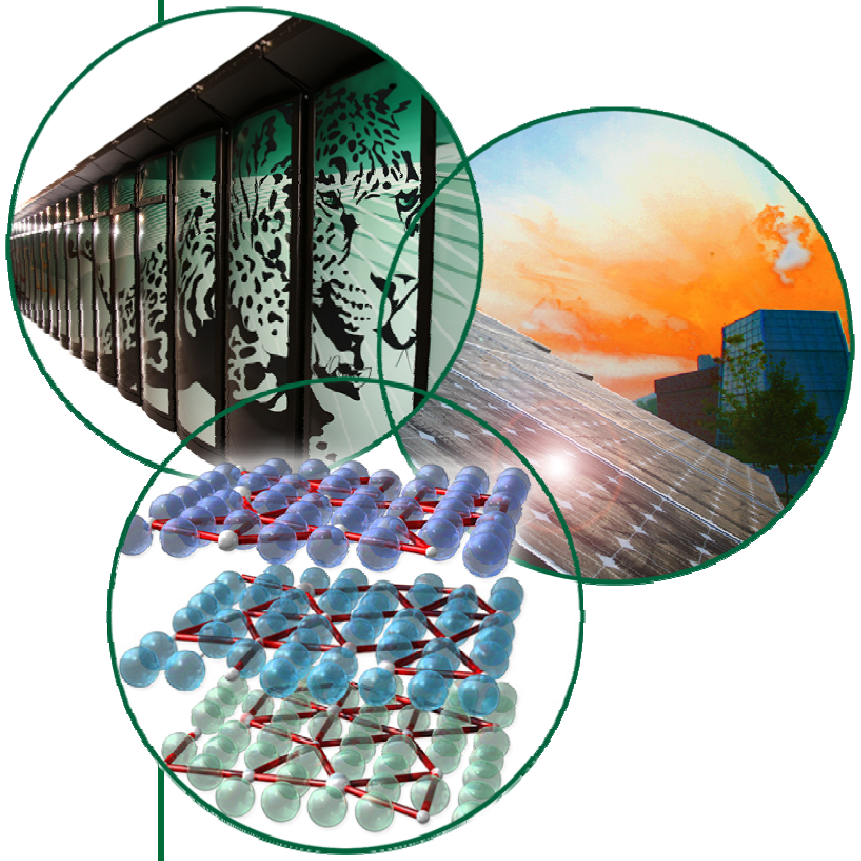
2012: The *TASCA* Element 119 Collaboration

GSI Darmstadt (D)	D. Ackermann, M. Block, F.P. Heßberger, A. Hübner, E. Jäger, B. Kindler, J. Krier, N. Kurz, B. Lommel, J. Runke, B. Schausten, J. Steiner, A. Yakushev
	EE / Ion source / Accelerator staff
Univ. Mainz (D)	Ch.E. Düllmann, A. Di Nitto, K. Eberhardt, S. Klein, J.V. Kratz, C. Mokry, D. Renisch, P. Thörle-Pospiech, N. Trautmann, N. Wiehl
HIM Mainz (D)	L.-L. Andersson, X. Derkx, J. Even, J. Khuyagbaatar, V. Yakusheva
ORNL / UT Knoxville (USA)	R. Grzywacz, D. Miller, J. Roberto, K. Rykaczewski
Vanderbilt U (USA)	J.H. Hamilton
LBNL / UC Berkeley (USA)	N. Esker, J.M. Gates, K.E. Gregorich, H. Nitsche, G.K. Pang
LLNL (USA)	N. Gharybian, J.M. Gostic, R.A. Henderson, K.J. Moody, D.A. Shaughnessy, E.E. Tereshatov
Lund Univ (S)	C. Fahlander, U. Forsberg, P. Golubev, D. Rudolph
Univ. Liverpool (UK)	D.M. Cox, R.-D. Herzberg, A. Mistry
SINP Kolkata (IND)	S. Lahiri, M. Maiti
JAEA Tokai (J)	M. Asai, M. Schädel
Univ. Oslo (N)	J.P. Omtvedt, A. Semchenkov
U Jyväskylä	J. Uusitalo
PSI / Univ. Berne (CH)	A. Türler, P. Steinegger
ITE Warsaw (PL)	M. Wegrzecki
ANU Canberra (AUS)	M. Evers, D. Hinde

Production of Bk-249 Target Material

Julie G. Ezold and Jeff L. Binder
Fuel Cycle and Isotope Division
Oak Ridge National Laboratory





Slides courtesy of J. Roberto, ORNL

U.S. DEPARTMENT OF ENERGY

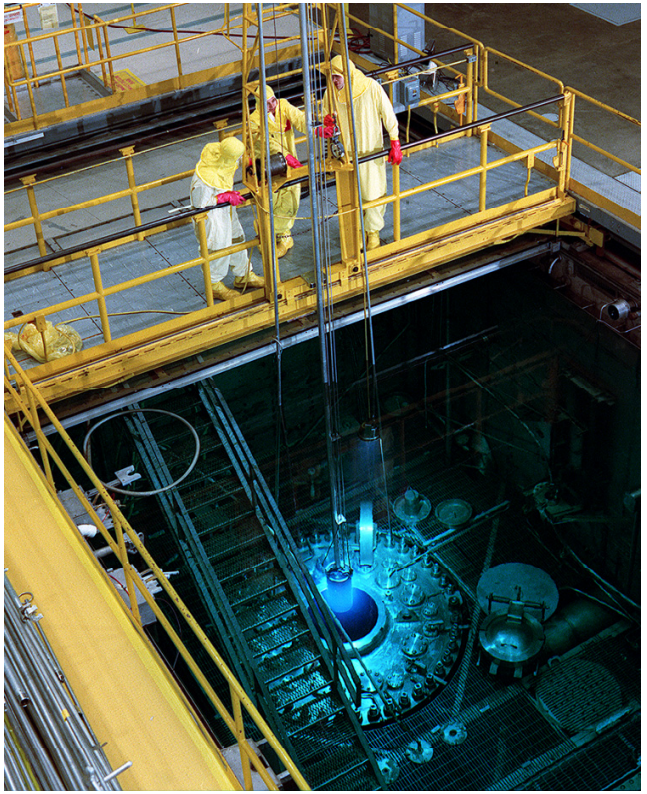
OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

^{249}Bk – Production

Irradiation of Am/Cm-targets in the HFIR @ ORNL

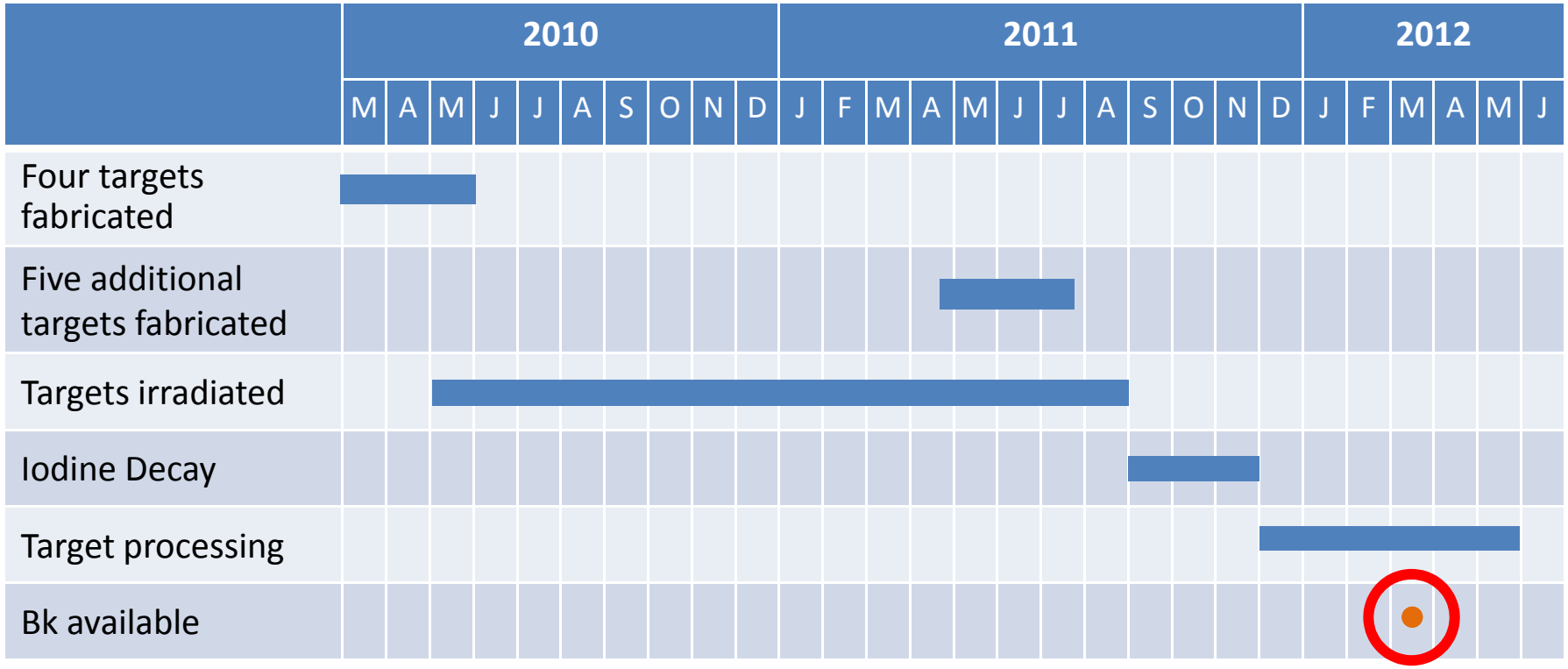
$\Phi_{thermal}$ at HFIR: 2.5×10^{15} neutrons/cm^2·s

- Targets remain in the reactor for approximately 18 months
- 31 target positions (10–13 targets typically irradiated)
- Produces ~35 mg ^{252}Cf per target (smaller quantities of Bk, Es, Fm)
- Chemical processing of irradiated targets and separation of Bk



OAK RIDGE National Laboratory

Timeline of Berkelium-249 Production

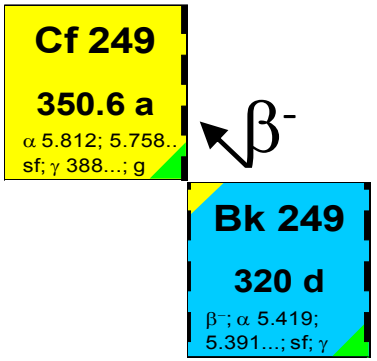


Bk-249 to be shipped the first week of March 2012

TASCA High Power Target Wheel used for E119 at GSI

Ø Target Wheel: 100 mm
Ø Beam Spot: 8 mm

Target wheel with Gd tested up to 2500 particle·nA



March 6:
^{249}Bk arrives in Mainz

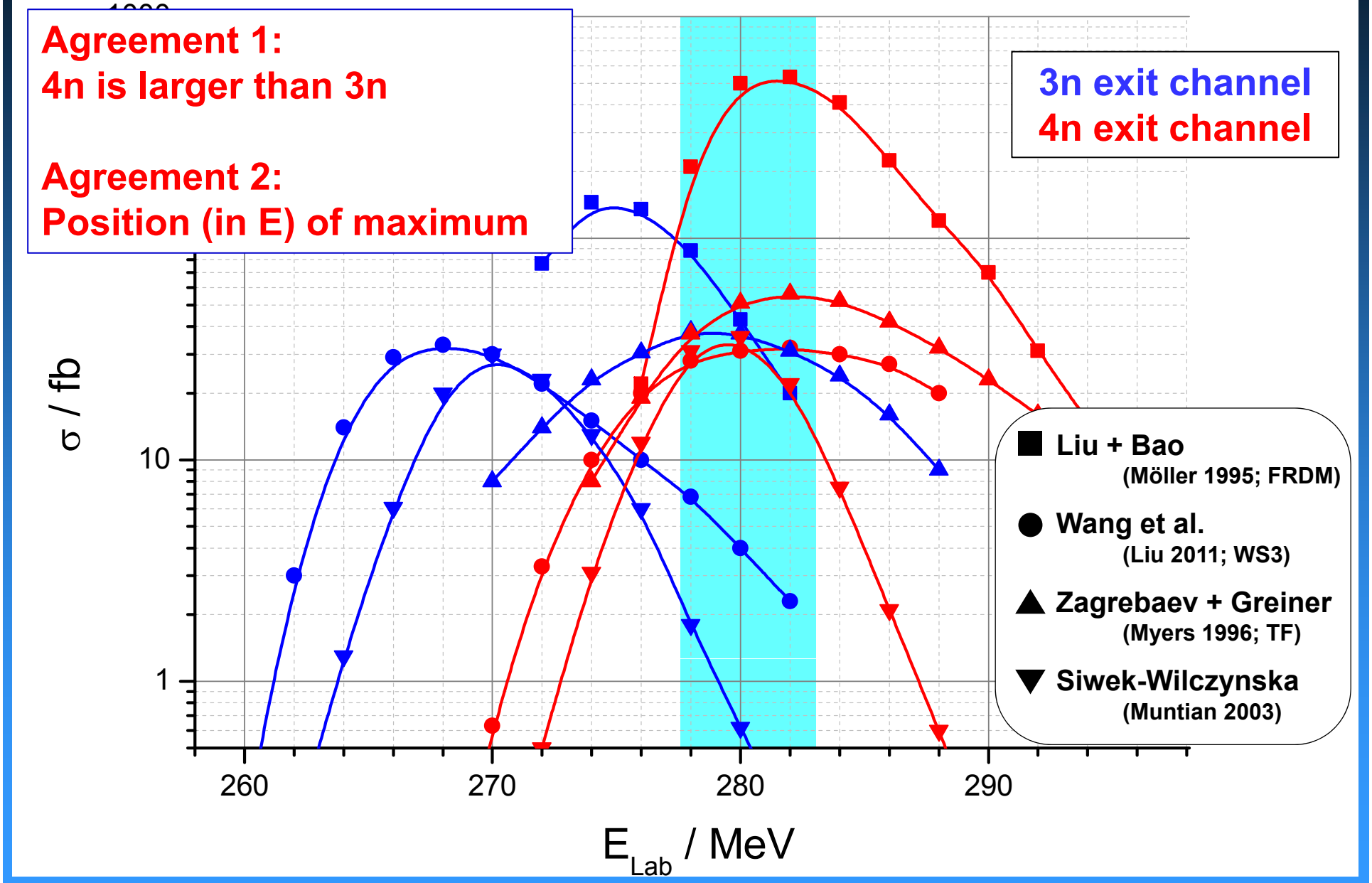
March 23:
Targets arrive at GSI

April 12:
Targets mounted in TASCA

April 14:
Begin Element 119 search

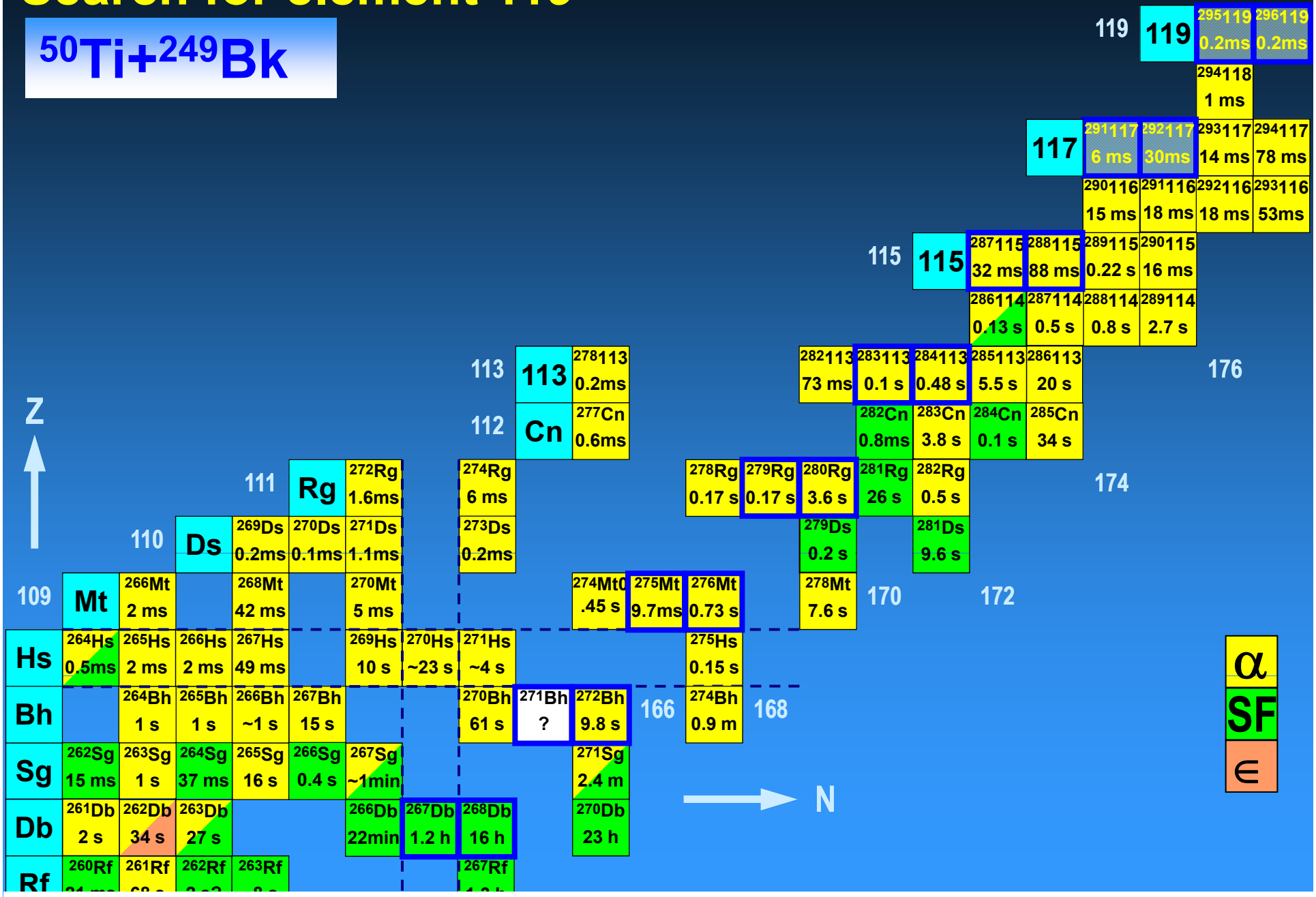
Wheel system: E. Jäger *et al.*, J. Radioanal. Nucl. Chem.; in print
Bk Target: J. Runke *et al.* J. Radioanal. Nucl. Chem.; in print

2012: $^{50}Ti+^{249}Bk$



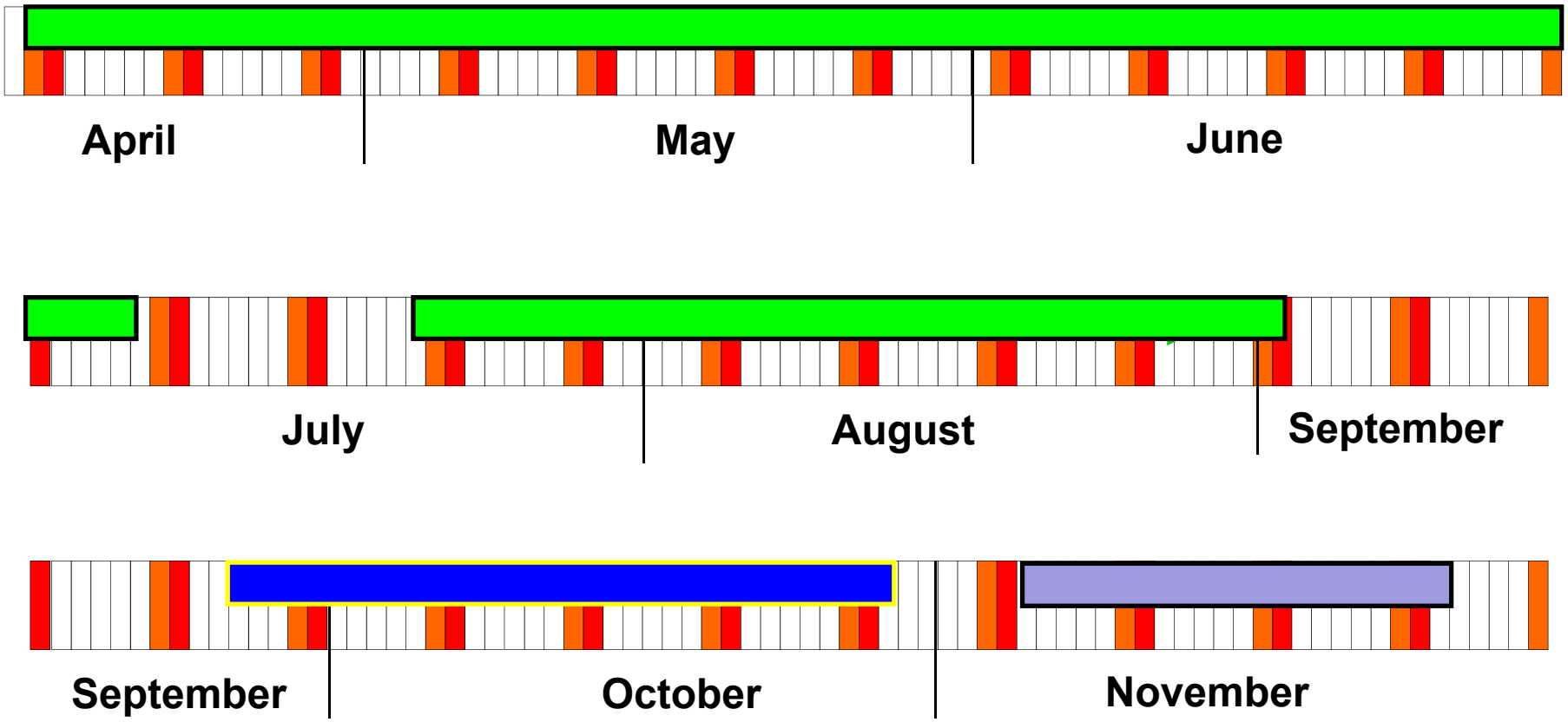
Search for element 119

$^{50}Ti+^{249}Bk$



2012: Elements 119 / 117 / 115

^{50}Ti beam 750 nA$_p$ and ^{249}Bk targets with initial thickness ≈0.44 mg/cm^2.

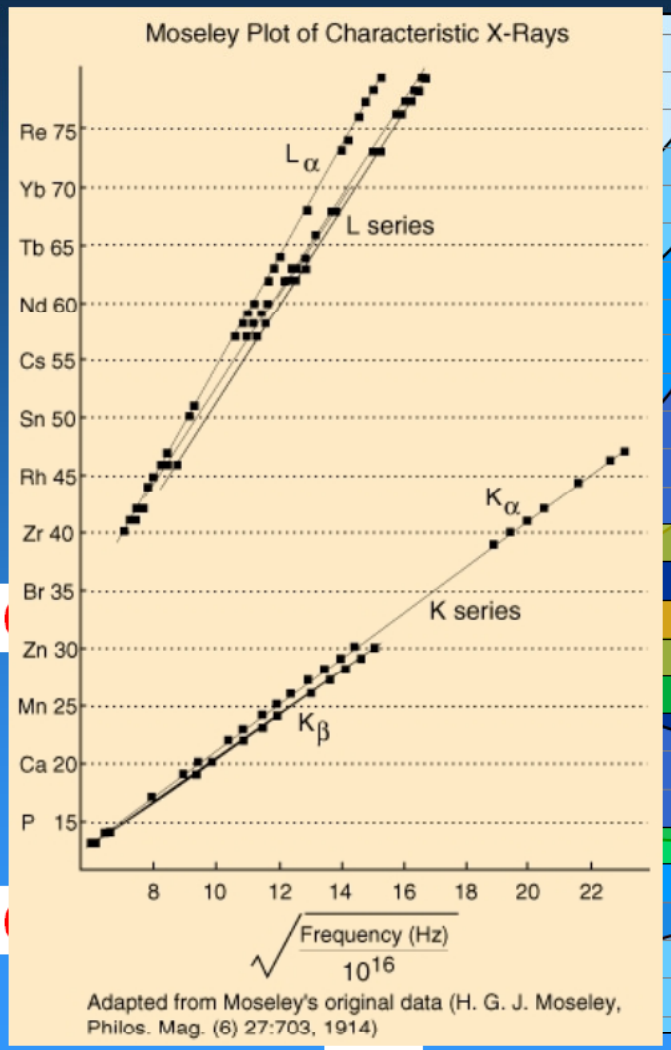


^{50}Ti+^{249}Bk⇒Element 119

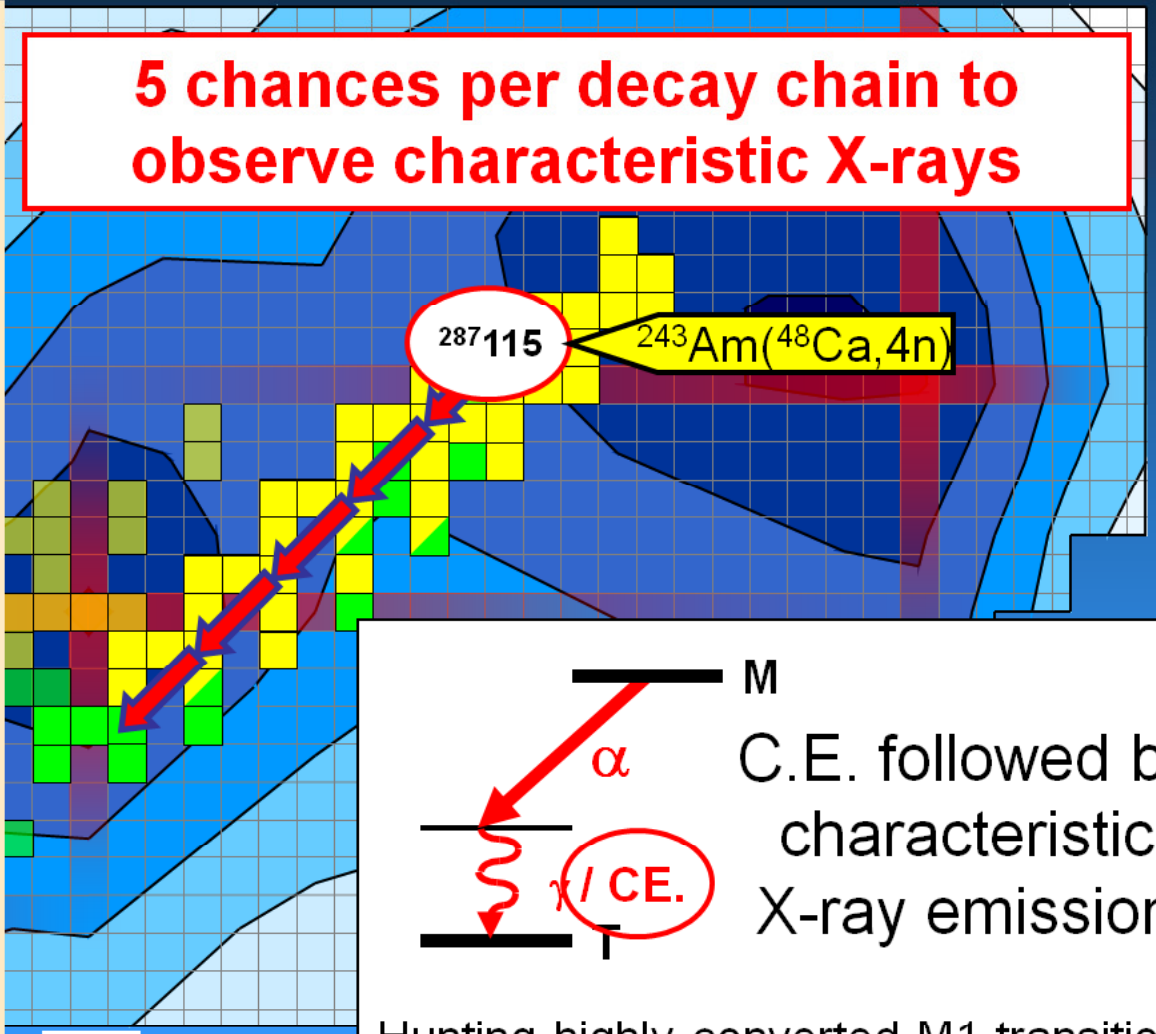
^{48}Ca+^{249}Bk⇒Element 117

^{48}Ca+^{243}Am⇒Element 115

Fingerprinting the SHE
- Direct measurement of Z



5 chances per decay chain to observe characteristic X-rays



C.E. followed by characteristic X-ray emission

Hunting highly converted M1 transitions!

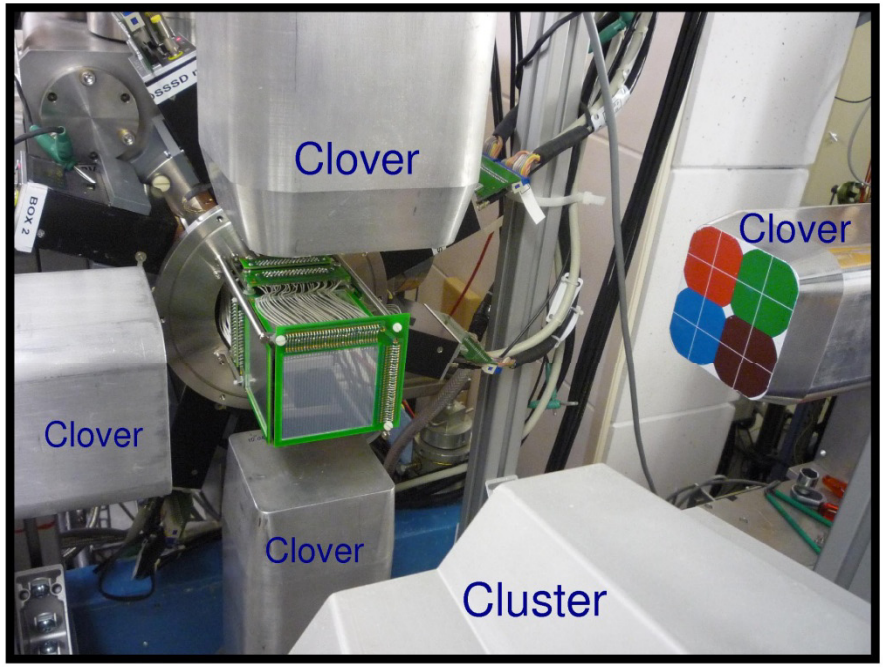
152 162

TASISpec

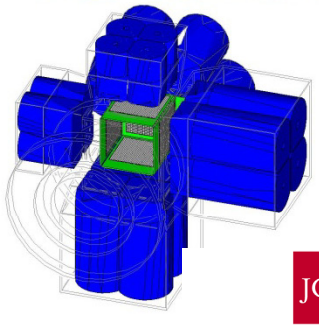
Highly efficient multi–coincidence spectroscopy set–up for TASCA's very compact focal plane image

1 Implantation DSSSD (1024 pixels)
4 box–DSSSDs (1024 pixels)
=> ~80% α–detection efficiency

4 Ge Clover (4*4 crystals)
1 Ge Cluster (7 crystals)
=> ~40% γ–detection eff. at 150 keV



L–L Andersson et al., NIM A 622, 164 (2010)
L.G. Sarmiento et al., NIM A 667, 26 (2011)



Virtually constructed with GEANT4 simulation package

JOHANNES GUTENBERG UNIVERSITÄT MAINZ
LUND UNIVERSITY
UNIVERSITY OF LIVERPOOL
HELMHOLTZ ASSOCIATION
Helmholtz Institute Mainz
GSI
UNIVERSIDAD NACIONAL DE COLOMBIA
OAK RIDGE NATIONAL LABORATORY
Managed by UT-Battelle for the Department of Energy

^{243}Am target material

Summary

- ***TASCA*** experiments 2011/12:
  - -focus: **search for elements 119 / 120** w/ ^{50}Ti reactions
  - -check **element 117**
  - -direct **Z measurement of ^{48}Ca+^{243}Am** chains (w/ TASISpec)